Procedures for Commercial Building Energy Audits

This publication was prepared under ASHRAE Research Project RP-669 and ASHRAE Special Project SP-56 in cooperation with TC 9.6, Systems Energy Utilization (now TC 7.6).

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Procedures for Commercial Building Energy Audits

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Contents

Preface

This publication has been developed as a result of two earlier assessments of the energy auditing process in commercial buildings by ASHRAE.[1, 2] Special Project 56 developed the scope of work for various levels of analysis, and Research Project 669 developed a standard format for reporting the results of analysis.

In combining the results of these assessments, the purpose of this publication is twofold:

1. To provide purchasers and providers of energy audit services with a complete definition of good procedures for an energy survey and analysis.
2. To provide a format for defining buildings and their energy use that will allow data to be shared in meaningful ways.

This publication addresses these needs through the description of typical procedures for each level of analysis and uniform means of reporting building, system, and energy use characteristics, as well as the results of the analysis.

No attempt has been made to prescribe field survey methods or the analytical tools to be used. This publication specifically avoids a "cookbook" approach, recognizing that all buildings are different and each analyst needs to exercise a substantial amount of judgment. Instead, this publication sets out generalized procedures to guide the analyst and the building owner and provides a uniform method of reporting basic information.

The readers' attention is called to the forms in sections entitled "Preliminary Energy Use Analysis" and "Walk-Through Data." These forms utilize standard definitions for building area, building type, and energy use. In addition, data are requested on the various space functions and systems in the building. By standardizing definitions and reporting methods, it is intended that the information requested can contribute to the establishment of a large, useful database of building functions and energy use. Highlighted areas on the forms were incorporated into a trial database by Research Project 669. Therefore, the analyst is urged to provide all possible information in these two sections in the format provided.

Other ASHRAE documents that would be useful in completing a comprehensive engineering energy analysis are:

- *2003 ASHRAE Handbook—HVAC Applications*, chapter 35, "Energy Use and Management" and chapter 40, "Building Energy Monitoring."
- ASHRAE Standard 100–1995, Energy Conservation in Existing Buildings.
- ASHRAE Standard 105–1984 (RA 90), Standard Methods of Measuring and Expressing Building Energy Performance.

1. An assessment of the Energy Auditing Process in Commercial Buildings, SP-56 Report to Pacific Northwest laboratory, December 1987.
2. ASHRAE Research Project 669: Evaluation of Proposed ASHRAE Energy Audit Forms and Procedures, 1997.

Acknowledgments

This publication is the result of ongoing efforts by the Systems Energy Utilization Technical Committee (TC 9.6 through most of the work on this project; renumbered to TC 7.6 in 2003) to develop definitions of good procedures for energy survey and analysis, and to provide a format for defining buildings and their energy use, to allow data to be shared in meaningful ways.

The effort to have the technical research of the TC made available in an ASHRAE Special Publication was led by TC member Dick Pearson. Significant input and leadership came from Ish Sud during his tenure as TC chair and since, and TC member John Cowan. Mike MacDonald, Bob Fuller, Hashem Akbari, Dieter Bartel, Wayne Robertson, and others, have provided useful comments along the process of development. The TC approved publication of the document in June 1999.

Adam Hinge
Chair, TC 7.6, Systems Energy Utilization
April 2004

The Energy Audit Process

OBJECTIVES

The objectives of an energy analysis or audit are to identify and develop modifications that will reduce the energy use and/or cost of operating a building. The results should be presented in a format that will provide the information needed by an owner/operator to decide if any, some, or all of the recommended modifications should be implemented. An energy analysis includes the following steps:

1. Collect and analyze historical energy use.
2. Study the building and its operational characteristics.
3. Identify potential modifications that will reduce the energy use and/or cost.
4. Perform an engineering and economic analysis of potential modifications.
5. Prepare a rank-ordered list of appropriate modifications.
6. Prepare a report to document the analysis process and results.

OUTLINE

The key elements of a commercial building energy audit/analysis are as follows:

1. Analysis of two or more years of utility consumption and cost, review of building plans, and a walk-through of the building itself to establish:
   - Type of building, principal use, and area, ft^2.
   - Energy Utilization Index (EUI): (annual energy use) $kBtu/ft^2$ per year.
   - Cost index: $\$/ft^2$ per year.
   - Breakdown of various spaces within the building by function, hours of use, and area.
   - Determine if efficiency may be affected by building functions that differ from the original functional intent of the building.
   - Determine if any maintenance problems or practices may affect efficiency.
   - Comparison of energy and cost indices of the building with one or more databases.
2. Description and analysis of the energy-using systems of the building, resulting from on-site observation, measurement, and engineering calculations, including:
   - Envelope
   - Lighting
   - HVAC
   - Domestic hot water
   - Laundry
   - Food preparation

- Conveying systems
- Other systems

3. As a result of engineering analysis and economic calculations, develop:
    - Breakdown of the components of annual energy use and cost.
    - Recommended energy conservation measures, including predicted savings and cost to implement.
    - A description and cost estimate of repairs that are needed in order for energy conservation measures to be effective.
    - A description and cost estimate of measurement and verification methods needed to determine the actual effectiveness of measures.
    - Energy analysis summary:
        - Present energy use and cost
        - Ultimate target for energy use and cost
        - Savings from recommended measures
        - Comparison of current recommendations to ultimate target

PROCEDURES

An engineering energy audit/analysis of a facility should provide sufficient information for the owner/operator and/or manager of a facility to understand the energy use characteristics of the building. This analysis breaks down the total energy use and cost for the facility into various end uses, such as heating, air conditioning, lighting, etc., and shows the potential for savings.

The engineering analysis should also provide the owner/operator with all information needed to commit necessary resources to reduce the building's energy use and/or cost. This includes outlining any changes in the facility's operation and maintenance, including different personnel requirements, as well as presenting an economic analysis of any capital improvement projects.

The engineering analyst is encouraged to follow a systematic approach in identifying, selecting, and ranking recommended measures. However, the appropriateness of a measure depends not only on technical issues but also on institutional and organizational issues, such as the regulatory environment, financing options, and occupant requirements. Therefore, a modification to a piece of equipment or an activity that is highly effective under some conditions may have little or no effect under others.

Different levels of energy analysis can be performed on any given building, or group of buildings, providing information that may be used for widely varying purposes. A building owner contemplating major energy-saving capital improvements will need a significantly higher level of confidence in the analysis than an owner who simply wishes to compare the level of efficiency of the building relative to other, similar buildings.

As a result, the levels of analysis have been organized into the following categories:

- Preliminary Energy Use Analysis
- Level I Analysis—Walk-Through Analysis
- Level II Analysis—Energy Survey and Analysis
- Level III Analysis—Detailed Analysis of Capital Intensive Modifications

The different levels are described here, along with the typical process of analysis and report contents for each level. Each succeeding level of analysis builds upon the previous level. A joint decision should be made by the building owner and energy analyst as to the level that is appropriate for the owner's needs.

This publication is intended to provide guidance to engineering energy analysts and to provide some standardization of the results of the analysis. It will also be useful to building owners and operating staff to provide an understanding of results that can be expected from the engineering analyst, as well as the level of analysis that may be appropriate for a facility.

ORGANIZING DATA

The forms to be used with an energy analysis are generalized and presented as ***sections*** of a typical report in subsequent portions of this publication. It is intended that the forms in each of the four sections be utilized whenever an energy analysis is performed, although a Level I analysis (walk-through) will make little or no use of the forms in the section on "Building and Systems Report." As the engineering analysis becomes more rigorous, so does the use of the forms. They are summarized in the following sections.

Preliminary Energy Use Analysis[1]

The utility data and general building characteristics required in the "Preliminary Energy Use Analysis" section can usually be obtained from the owner/operator of the building before a visit to the building. The forms can be used to develop energy and cost indices, to compare with similar buildings and to make a rough determination of the benefits of further analysis.

Walk-Through Data[1]

The information required in the "Walk-Through Data" section includes information on space functions and systems, which can be obtained without conducting a detailed analysis of the building. Highlighted areas in these sections have been incorporated into a trial database by ASHRAE Research Project 669.

Building and Systems Report

This section is intended to provide guidance to the analyst as to the type of information to be collected and presented. No attempt is made to suggest methods of data collection or to specify a format for presentation.

Energy Analysis Summary and Recommendations

This section provides a format for reporting the results and recommendations of an analysis, including a component breakdown of energy use and recommended energy conservation measures, accompanied by an estimate of capital cost and savings for each recommendation. System interaction must be properly accounted for when combining more than one modification. The economics of each modification may vary, depending upon the order in which they are accomplished.

1. The development of the uniform reporting methods in these two sections will facilitate sharing of data and may eventually lead to the development of a building energy and functional usage database for use by the profession.

Levels of Effort

Depending on the physical and energy-use characteristics of a building and the needs and resources of the owner, these steps can require different levels of effort. A commercial building energy analysis can generally be classified into the following levels of effort.

OVERVIEW

Preliminary Energy Use Analysis

Analyze historic utility use and cost. Develop the Energy Utilization Index (EUI) of the building. Compare the building EUI to similar buildings to determine if further engineering study and analysis are likely to produce significant energy savings.

Level I—Walk-Through Analysis

Assess a building's energy cost and efficiency by analyzing energy bills and conducting a brief on-site survey of the building. A Level I energy analysis will identify and provide a savings and cost analysis of low-cost/no-cost measures. It will also provide a listing of potential capital improvements that merit further consideration, and an initial judgment of potential costs and savings. A walk-through analysis of a facility will utilize all the forms in this publication except those in the section on "Building and Systems Report."

Level II—Energy Survey and Analysis

This includes a more detailed building survey and energy analysis. A breakdown of the energy use within the building is provided. A Level II energy analysis will identify and provide the savings and cost analysis of all practical measures that meet the owner's constraints and economic criteria, along with a discussion of any changes to operation and maintenance procedures. It may also provide a listing of potential capital-intensive improvements that require more thorough data collection and engineering analysis, and a judgment of potential costs and savings. This level of analysis will be adequate for most buildings and measures.

Level III—Detailed Analysis of Capital-Intensive Modifications

This level of engineering analysis focuses on potential capital-intensive projects identified during the Level II analysis and involves more detailed field data gathering as well as a more rigorous engineering analysis. It provides detailed project cost and savings calculations with a high level of confidence sufficient for major capital investment decisions.

Discussion

There are not sharp boundaries between these levels. They are general categories for identifying the type of information that can be expected and an indication of the level of confidence in the results. It is possible that while performing an energy analysis in a particular building, various measures may be subjected to different levels of analysis.

Some readers of an energy analysis report may be unable to comprehend the technical analysis involved, while others may demand a full presentation of the analysis for critique. Consequently, technical material should be presented in an appendix to the report, while the body of the report guides the reader through the technical material and summarizes the findings.

Information presented here outlines the engineering procedures that should be followed while performing an energy analysis. It is assumed that the analyst is a knowledgeable and competent individual. No attempt is made in this publication to prescribe specific methods of data gathering or data analysis.

To assist with the organization of the data collected and the calculation procedures, this publication contains guideline forms that suggest the type of data to be gathered and its organization. It is recommended that the analyst develop and use appropriate data collection and organization forms specific to the size and type of building(s) being analyzed.

The forms presented in the first two sections are building characteristic forms on which basic building information and energy use can be recorded. Use of these forms by all engineering analysts will result in a uniform procedure for reporting the results of an analysis. It is recommended that these forms be completed without modification.

PRELIMINARY ENERGY USE ANALYSIS

Before any level of energy analysis is begun, it is valuable to perform a preliminary energy use analysis to determine a building's current energy and cost efficiency relative to other, similar buildings. This is normally done by calculating the energy use and cost per square foot per year, which can indicate the potential value of further levels of analysis. This preliminary analysis generally includes the following steps.

1. Determine the building's gross conditioned square footage and record this on the building characteristics form. Classify the primary use of the building. Ensure that the standard definition of gross area is used.
2. Assemble copies of all utility bills and summarize them for at least a one-year period, preferably three years. Review the monthly bills for opportunities to obtain a better price through taking advantage of different utility rate classes. Review the monthly patterns for irregularities. Note if a bill is missing or if it is estimated rather than actual consumption.
3. Complete the energy performance summary to develop the energy index and the cost index for each fuel, or demand type, and their combined total using ASHRAE Standard 105 methods.
4. Compare the Energy Utilization Index (EUI) and the cost index with buildings having similar characteristics. The owner of the subject building may have similar buildings for this comparison. Comparison should also be made with publicly available energy indices of similar buildings. In all cases, care should be taken to ensure that comparison is made with current data, using consistent definitions of building usage and floor area.
5. Derive target energy, demand, and cost indices for a building with the same characteristics as this building. A range of methods are available for this work:
    - Pick from any database of similar buildings those buildings with the lowest energy index.
    - Pick an index based on the knowledge of an energy analyst experienced with this type of building.
6. Compare the energy and cost savings for each fuel type if the building were to reach the target Energy Utilization Index. Using these value(s), determine if further engineering analysis is recommended.

LEVEL I—WALK-THROUGH ANALYSIS

This process includes all of the work done for the preliminary energy use analysis, plus the following.

1. Perform a brief walk-through survey of the facility to become familiar with its construction, equipment, operation, and maintenance.
2. Meet with owner/operator and occupants to learn of special problems or needs of the facility. Determine if any maintenance problems and/or practices may affect efficiency.
3. Perform a space function analysis, guided by the forms in the "Walk-Through Data" section. Determine if efficiency may be affected by functions that differ from the original functional intent of the building.
4. Perform a rough estimate to determine the approximate breakdown of energy use for significant end-use categories, including weather and non-weather-related uses.
5. Identify low-cost/no-cost changes to the facility or to operating and maintenance procedures, and determine the savings that will result from these changes.
6. Identify potential capital improvements for further study, and provide an initial estimate of potential costs and savings.

The report for a Level I analysis should contain the building characteristics and energy use summary as well as the following.

1. Quantification of savings potential from changing to a different utility price structure.
2. Discussion of irregularities found in the monthly energy use patterns, with suggestions about their possible causes.
3. The energy index of similar buildings. Report the source, size, and date of the sample used in this comparison. The names of comparable buildings should be given if known.
4. The method used to develop the target indices. Where comparison is made to other buildings, state their names. Where the experience of someone other than the author is used to develop the target, provide the source. Where the target is developed by calculation, show the calculation or quote the name and version of software used and include both input and output data.
5. Total energy and demand cost by fuel type for the latest year and preceding two years if available. Show potential savings in dollars using the energy index format of ASHRAE Standard 105.
6. The fraction of current costs that would be saved if the energy index were brought to the target level.
7. A summary of any special problems or needs identified during the walk-through survey, including possible revisions to operating and maintenance procedures.
8. A preliminary energy use breakdown by major end uses.
9. The listing of low-cost/no-cost changes with the savings for these improvements.
10. The potential capital improvements, with an initial estimate of potential costs and savings

LEVEL II—ENERGY SURVEY AND ENGINEERING ANALYSIS

This analytical procedure is guided by Level I analysis and includes the following additional work:

1. Review mechanical and electrical system design, installed condition, maintenance practices, and operating methods. Where drawings have been kept up to date, this task will be much easier.

2. Review existing operating and maintenance problems. Determine planned building changes.
3. Measure key operating parameters and compare to design levels, for example, operating schedules, heating/cooling water temperature, supply air temperature, space temperature and humidity, ventilation quantities, and light level at the task. Such measurements may be taken on a spot basis, or logged, manually or electronically.
4. Prepare a breakdown of the total annual energy use into end-use components, as illustrated in the *1999 ASHRAE Handbook—Applications*, Chapter 34, Figure 4, or as shown in the section "Energy Analysis Summary and Recommendations." A number of calculation methods are available, ranging from simplified manual calculations to fully detailed computer simulation of hour-by-hour building operations for a full year.
5. List all possible modifications to equipment and operations that would save energy. Select those that might be considered practical by the owner. List preliminary cost and savings estimates.
6. Review the list of practical modifications with the owner/operator and select those that will be analyzed further. Prioritize the modifications in the anticipated order of implementation.
7. For each practical measure, estimate the potential savings in energy cost and its energy index. To account for interaction between modifications, assume that modifications with the highest operational priority and/or best return on investment will be implemented first. A number of calculation methods are available, ranging from simplified manual calculations to rerunning computer simulations, if performed in Step 4, above.
8. Estimate the cost of each practical measure.
9. Estimate the impact of each practical measure on building operations, maintenance costs, and non-energy operating costs.
10. Estimate the combined energy savings from implementing all of the practical measures and compare to the potential derived in the Level I analysis. It should be clearly stated that savings from each modification are based on the assumption that all previous modifications have already been implemented and that the total savings account for all of the interactions between modifications.
11. Prepare a financial evaluation of the estimated total potential investment using the owner's chosen techniques and criteria. These evaluations may be performed for each practical measure.
12. Following submission of the report of the Level II analysis, meet with the owner to discuss priorities and to help select measures for implementation or further analysis.

The report for a Level II analysis should contain at least the following.

1. A summary of energy use and cost associated with each end-use. Show calculations performed or quote the name and version of software used and include both input and output pages. Provide interpretation of differences between actual total energy use and calculated or simulated end-use totals.
2. A description of the building, including typical floor plans and inventories of major energy-using equipment. (This information may be included as an appendix.)
3. A list of measures considered but felt to be impractical, with brief reasons for rejecting each.
4. For each practical measure, provide
    - a discussion of the existing situation and why it is using excess energy;
    - an outline of the measure, including its impact on occupant health, comfort, and safety;

- a description of any repairs that are required for a measure to be effective;
- the impact on occupant service capabilities, such as ventilation for late occupancy or year-round cooling;
- an outline of the impact on operating procedures, maintenance procedures, and costs;
- expected life of new equipment, and the impact on the life of existing equipment;
- an outline of any new skills required in operating staff and training or hiring recommendations;
- calculations performed or provide the name and version of software used and include both input and output data.

5. A table listing the estimated costs for all practical measures, the savings, and financial performance indicator. For the cost of each measure, show the estimated accuracy of the value quoted. This table should spell out the assumed sequence of implementation and state that savings may be quite different if a different implementation sequence is followed.
6. A discussion of any differences between the savings projected in this analysis and the estimated potential derived in the Level I analysis.
7. Overall project economic evaluation.
8. Recommended measurement and verification method(s) that will be required to determine the actual effectiveness of the recommended measures.
9. Discussion of feasible capital-intensive measures that may require a Level III analysis.

LEVEL III—DETAILED ANALYSIS OF CAPITAL-INTENSIVE MODIFICATIONS

This analytical procedure is guided by Levels I and II analyses and the owner's selection of measures for greater definition. It must follow such Level I and II work.

1. Expand definition of all modifications requiring further analysis.
2. Review measurement methods, and perform additional testing and monitoring as required to allow determination of feasibility.
3. Perform accurate modeling of proposed modifications. Ensure that modeling includes system interaction.
4. Prepare a schematic layout of each of the modifications.
5. Estimate the cost and savings of each modification.
6. Meet with owner to discuss/develop recommendations.

The report for a Level III analysis should include the following, as a minimum.

1. Include text, schematics, and equipment lists necessary to completely describe all proposed changes to physical equipment. Matters of a final design nature may be left to subsequent engineering as long as the cost of such engineering is included in the budget. Firm price contractor quotations for key parts of any measure may be included. Cost estimates shall show contingencies separately and report the expected accuracy of the budget.
2. Prepare a financial evaluation of the estimated capital investment and projected savings. Use the owner's chosen techniques and criteria.

Guideline Forms

The following pages illustrate the suggested arrangement and content in providing a complete energy analysis report and recommendations. In this portion of this publication, explanatory material is included on the forms.

Preliminary Energy Use Analysis

The data required in this section can usually be obtained from the owner/operator of the building before a visit to the building. The forms utilize standard definitions for building area, building type, and energy use. The result is the development of energy and cost indices, which can be used to compare with other, similar buildings, and to make a rough determination of the benefit of further analysis.

It is intended that the information requested can contribute to the establishment of a useful database of building energy use. Therefore, the analyst is strongly urged to provide all possible information ***in the format provided***. Shaded areas indicate information that is input into the database.

BUILDING CHARACTERISTICS

Building ID ____ Date of Audit:__________________

City ______________________________ State/Prov.________________ Zip/Post__________________

Lat. ________ Long. _________ HDD _______ CDD _____ (Base 65°F) ______ (Year of Data)

Gross Floor Area, [1] ___________ft^2 Total Conditioned Area[1] ____________ft^2

Conditioned Area, [1] heated only _______ft^2 Conditioned Area, [1] cooled only ________ft^2

Conditioned Area, [1] heated & cooled _______ft^2

Number of conditioned floors: Above grade _______ Below grade _________

Year of Construction[2]: __________

Brief Building Description: ____

PRIMARY BUILDING TYPE[3] (check one only)

Office
- 11 [ ] Owner Occupied
- 12 [ ] Leased (1-5 Tenants)
- 13 [ ] Leased (5+ Tenants)
- 19 [ ] Other—Define

Hotel/Motel
- 21 [ ] Motel (No Food)
- 22 [ ] Hotel
- 23 [ ] Hotel/Convention
- 29 [ ] Other—Define

Apartment
- 31 [ ] General Occupancy
- 32 [ ] Seniors Only
- 39 [ ] Other—Define

Education
- 41 [ ] Primary
- 42 [ ] Secondary
- 43 [ ] University
- 49 [ ] Other—Define

Food Services
- 51 [ ] Restaurant - Full Service
- 52 [ ] Fast Food
- 53 [ ] Take Out
- 54 [ ] Lounge
- 59 [ ] Other—Define

Health Care
- 61 [ ] Nursing Home
- 62 [ ] Psychiatric
- 63 [ ] Clinic
- 64 [ ] Active Treatment Hospital
- 69 [ ] Other—Define

Retail
- 71 [ ] Drycleaning
- 72 [ ] Supermarket
- 73 [ ] General Merchandise
- 74 [ ] Shopping Mall Without Tenant Loads
- 75 [ ] Shopping Mall Without Tenant Lighting Loads
- 76 [ ] Shopping Mall
- 77 [ ] Specialty Shop
- 78 [ ] Bakery
- 79 [ ] Other—Define

Assembly
- 81 [ ] Theatre
- 82 [ ] Museum/Gallery
- 83 [ ] Church/Synagogue
- 84 [ ] Arena/Gym
- 85 [ ] Arena/Rink
- 89 [ ] Other—Define

Other
- 91 [ ] Laboratory
- 92 [ ] Warehouse
- 93 [ ] Warehouse—Refrigerated
- 94 [ ] Recreation/Athletic Facility
- 95 [ ] Jail
- 96 [ ] Transport Terminal
- 97 [ ] Multi-Use. Complex
- 99 [ ] Other—Define

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1. GROSS FLOOR AREA is all floor area contained within the outside finished surface of permanent outer building walls including basements, mechanical equipment floors, and penthouses (*ANSI Standard Z65.1-1996, Construction Area*). No exclusions are made for shafts, stairs, or atria. CONDITIONED AREA is that area provided with heating or cooling to maintain temperature between 50°F and 86°F (*ANSI/ASHRAE Standard 105-1984*).
2. THE MEDIAN YEAR for construction of at least 51% of the conditioned space.
3. BUILDING TYPE as characterized by at least 51% of the conditioned space.

ENERGY PERFORMANCE SUMMARY ___________ (YEAR)

This is a summary of energy account worksheets on succeeding pages.

ENERGY TYPE	TOTAL ANNUAL USE	UNITS	CONVERSION MULTIPLIER To Thousands Btu See Page 17	THOUSANDS BTU (kBtu)	TOTAL ANNUAL COST ($)
ELECTRICITY					
NATURAL GAS					
PURCHASED STEAM					
PURCHASED HOT WATER					
PURCHASED CHILLED WATER					
OIL # _______					
PROPANE					
COAL					
OTHER					
				A	B

ENERGY AND COST INDICES

Energy Utilization Index (A ÷ Gross Floor Area) ________________________ $kBtu/ft^2/yr$

Cost Index (B ÷ Gross Floor Area) ____________________________________ $\$/ft^2/yr$

Total Water Use (C) ________ kGal/yr or _______ ft^3/yr _______ $/yr

Cost Index, Including Water (B + C) ÷ (Gross Floor Area)__________________ $\$/ft^2/yr$

ANALYSIS OF METERED ELECTRICAL DEMAND

Maximum Demand _______ kW or _______ kVA ________ (month)

Maximum Demand _______ kW × 1000 ÷ Gross Floor Area = ________ W/ft^2

Minimum Demand _______ kW or ________ kVA _______ (month)

Minimum Demand _______ kW × 1000 ÷ Gross Floor Area = _______ W/ft^2

Comparison with Similar Building(s)

	EUI kBtu/ft²/yr	Annual Cost $/ft²/yr	Max. Demand W/ft²	Min. Demand W/ft²
THIS BUILDING (ID# ____________):	____________	____________	____________	____________
COMPARISON BUILDING/DATABASE[1]:	____________	____________	____________	____________

Discussion of comparative data:

____
____
____
____

Further analysis recommended? Y/N ______________

Explain ____

1. Source of Data: ____

CONVERSION MULTIPLIERS

(Thousands of Btu)
(Refer to ASHRAE Standard 105-1984 for unusual fuels)

Fuel	Measured Units	Conversion Multiplier
Electricity	kWh	3.413
	MWh	3413
Natural Gas	CCF	103
	MCF	1030
	Therm	100
	Cubic Meter	36.4
	Gigajoule	947.8
Purchased Steam	1000 Btu	1.0
	1000 lb	1000
	Therm	100
Purchased Hot Water	1000 Btu	1.0
Purchased Chilled Water	1000 Btu	1.0
	Ton-Hour	12.0
Oil #2	U.S. Gallon	139
	Imp. Gallon	167
	Liter	36.7
Oil #6	U.S. Gallon	154
	Imp. Gallon	185
	Liter	40.7
Propane	U.S. Gallon	91.6
	Imp. Gallon	110
	Liter	24.2
Anthracite Coal	Ton	25,400

WATER VOLUME CONVERSION

U.S. Gallons × 0.1337 = ft^3
Imperial Gallons × 0.1605 = ft^3

Preliminary Building Use [1]

Average Hours/Week ____________________ Average Weeks/Year ____________

Average Number of Occupants During Normal Occupied Period _____________

After Hours Cleaning (y/n) ________

Overall Building Schedule

Schedule during months of ___________________________

Days	**M**	**T**	**W**	**Th**	**F**	**Sat**	**Sun**	**Hol.**
Hours Open								
Hours Closed								
Peak no. of occupants								
Avg. no. of occupants when open								

Schedule during months of __________________________

Days	**M**	**T**	**W**	**Th**	**F**	**Sat**	**Sun**	**Hol.**
Hours Open								
Hours Closed								
Peak no. of occupants								
Avg. no. of occupants when open								

1. Use for at least 51% of the conditioned space.

PRELIMINARY ENERGY ALLOCATION TO END USES

	Energy Type (from energy performance summary)	
End Use	**Primary**	**Secondary (more than 5% of end use)**
Heating	___________	__________
Cooling	___________	__________
Domestic Water Heating	___________	__________
Kitchen Cooking Equipment	___________	__________
Laundry Equipment	___________	__________
Other Processing Equipment	___________	__________

METERED CONSUMPTION MONTHLY DATA: _________(YEAR)

Utility Company ____________________ Account #___________________ Rate Number_____________
Energy Type __________________ Consumption Units[1] ___________________
Electric Measured Demand Units[2] _________________________

	METERING PERIOD DAY/MONTH/ YEAR				ELECTRICITY ONLY		COST[3]		
From	**To**	**# of days**	**CONSUMPTION**	**"E" IF ESTIMATE**	**Measured Demand**	**Billed Demand**	**Consumption $**	**Demand $**	**Total $**
Total									

1. CCF, therms, kWh, gal, etc.
2. kW, kVA, etc.
3. Costs should include taxes, fees, contract charges, etc.

DELIVERED CONSUMPTION MONTHLY DATA __________ (YEAR)

Utility Company___________________ Account #_________________ Rate Number______________

Energy Type _________________ Consumption Units[1] __________________

DELIVERY DATE	DELIVERY AMOUNT	TOTAL COST[2]
0	------------	------------
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
USE OF INVENTORY	C	D
TOTAL CONSUMPTION		

USE OF INVENTORY (C)

At Date 0 _____________ (A)

365 Days After Date 0 _________ (B)

Use of Inventory (A-B) ________ (C)

VALUE OF INVENTORY USED

Latest Price ________________ (D)

Value (C × D) ______________

1. gal, lbs, etc.
2. Costs should include tax, fees, contract charges, etc.

Walk-Through Data

The information required in this section, can be obtained without conducting a detailed analysis of the building. A major goal of data collected in this section is to define the various space functions in the building. This information, in conjunction with specific information on the building itself, the HVAC system type(s), and the lighting system(s), will enable the analyst to commence a more detailed assessment of building energy performance.

It is intended that the information requested contribute to the establishment of a useful database of building functions and energy use. Therefore, the analyst is strongly urged to provide all possible information ***in the format provided***. Shaded areas indicate information that is input into the database.

SPACE FUNCTION AND SYSTEM SUMMARY

SPACE NUMBER[1]	A	B	C	D	E	F	UNACCOUNTED
FUNCTION TYPE[2]							
CONDITIONED AREA, ft^2							
SPACE USE [3] h/wk							
wks/yr							
PRINCIPAL LIGHTING TYPE							
PRINCIPAL TERMINAL HVAC TYPE							

REVISIONS TO ORIGINAL BUILDING FUNCTIONS

Discuss/describe revisions to the original functions of the building pertaining to current energy efficiency or longevity.

____

____

____

FUNCTION TYPES

Auditorium
- 1 Auditorium

Corridor
- 2 Corridor

Classroom/Lecture Hall
- 3 Classroom/Lecture Hall

Electrical/Mechanical Equipment Room
- 4 General
- 5 Control Room

Food Service
- 6 Fast Food/Cafeteria
- 7 Leisure Dining
- 8 Bar/Lounge
- 9 Kitchen

Recreation/Lounge
- 10 Recreational/Lounge

Stair
- 11 Active Traffic
- 12 Emergency Exit

Toilet and Washroom
- 13 Toilet and Washroom

Garage
- 14 Auto and Pedestrian Circulation
- 15 Parking Area

Laboratory
- 16 Laboratory

Library
- 17 Audio Visual
- 18 Stack Area
- 19 Card Filing & Cataloging
- 20 Reading Area

Lobby (General)
- 21 Reception and Waiting
- 22 Elevator Lobbies

Atrium (Multi-Story)
- 23 First Three Floors
- 24 Each Additional Floor

Locker Room and Shower
- 25 Locker Room and Shower

Offices (Partitions > 4.5 ft below ceiling) open plan offices without partitions or with partitions more than 4.5 ft below the ceiling. Offices < 900 ft^2.
- 26 Reading, Typing and Filing
- 27 Drafting
- 28 Accounting

Offices (Partitions 3.5 - 4.5 ft below ceiling) Open plan offices > 900 ft^2 with partitions 3.5 to 4.5 ft below the ceiling.
- 29 Reading, Typing and Filing
- 30 Drafting
- 31 Accounting

---

1. Separate zones with at least 10% of conditioned space.
2. Major space function types.
3. See detailed usage schedule.

Offices (Partitions < 3.5 ft below ceiling) Enclosed offices > 900 ft^2 with partitions within 3.5 ft of the ceiling

- 32 Reading, Typing, and Filing
- 33 Drafting
- 34 Accounting

Common Activity Areas

- 35 Conference/Meeting Room
- 36 Computer/Office Equipment
- 37 Inactive Filing
- 38 Mail Room

Shop (Non-Industrial)

- 39 Machinery
- 40 Electrical/Electronic
- 41 Painting
- 42 Carpentry
- 43 Welding

Storage and Warehouse

- 44 Inactive Storage
- 45 Bulky Active Storage
- 46 Fine Active Storage
- 47 Material Handling

Unlisted Space

- 48 Unlisted Space

Airport, Bus, and Rail Station

- 49 Baggage Area
- 50 Concourse/Main Thruway
- 51 Ticket Counter
- 52 Waiting and Lounge Area

Bank

- 53 Customer Area
- 54 Banking Activity Area

Barber and Beauty Parlor

- 55 Barber and Beauty Parlor

Church, Synagogue, Chapel

- 56 Worship/Congregational
- 57 Preaching and Sermon/Choir

Dormitory

- 58 Bedroom
- 59 Bedroom with Study
- 60 Study Hall

Fire and Police Department

- 61 Fire Engine Room
- 62 Jail Cell

Hospital/Nursing Home

- 63 Corridor
- 64 Dental Suite/Exam/Treatment
- 65 Emergency
- 66 Laboratory
- 67 Lounge/Waiting Room
- 68 Medical Supplies
- 69 Nursery
- 70 Nurse Station
- 71 Occupational/Physical Therapy
- 72 Patient Room
- 73 Pharmacy
- 74 Radiology

Surgery and O.B. Suites

- 75 General Area
- 76 Operating Room
- 77 Recovery

Hotel/Conference Center

- 78 Banquet/Multipurpose Room
- 79 Bathroom/Powder Room
- 80 Guest Room
- 81 Public Area
- 82 Exhibition hall
- 83 Conference/Meeting
- 84 Lobby
- 85 Reception Desk

Laundry

- 86 Washing
- 87 Ironing and Sorting

Museum and Gallery

- 88 General Exhibition
- 89 Inspection/Restoration
- 90 Inactive Artifacts Storage
- 91 Active Artifacts Storage

Post Office

- 92 Lobby
- 93 Sorting and Mailing

Service Station/Auto Repair

- 94 Service Station

Theater

- 95 Performance Arts
- 96 Motion Picture
- 97 Lobby

Retail establishments (Merchandising and Circulation Area) applicable to all lighting, including accent and display lighting, installed in merchandising and circulation areas.
- 98 Type A (Mass Merchandising)
- 99 Type B (Service Retail)
- 100 Type C (Mixed Use Retail)
- 101 Type D (Specialty Shop)
- 102 Type E (Fine Merchandise)
- 103 Type F (Service Establishment)
- 104 Mall Concourse

Retail Support
- 105 Tailoring
- 106 Dressing/Fitting Rooms

All Sports
- 107 Seating Area

Badminton
- 108 Club
- 109 Tournament

Basketball/Volleyball
- 110 Intramural
- 111 College
- 112 Professional

Bowling
- 113 Approach Area
- 114 Lanes

Boxing/Wrestling (Platform)
- 115 Amateur
- 116 Professional

Gymnasium
- 117 General Exercise and Recreation

Handball/Racquetball/Squash
- 118 Club
- 119 Tournament

Ice Hockey
- 120 Amateur
- 121 College/Professional

Skating Rink
- 122 Recreational
- 123 Exhibition/Professional

Swimming
- 124 Recreational
- 125 Exhibition
- 126 Underwater

Tennis
- 127 Recreational (Class III)
- 128 Club/College (Class II)
- 129 Professional (Class I)

Table Tennis
- 130 Club
- 131 Tournament

HVAC Types

30 Single Zone
31 Multi Zone
32 Dual Duct
33 Variable Air Volume
34 Reheat
35 Fan Coil Units
36 Unit Ventilators
37 Packaged Terminal Air Conditioner
38 Steam/Hot Water Radiator/ Convector
39 Above system(s) w/Economizer

Lighting Types

1 Fluorescent
2 Incandescent
3 Mercury Vapor
4 Sodium
5 Metal Halide
6 Other

DETAILED USAGE SCHEDULE
(OPTIONAL)

Usage Schedule for Each Major Space Type

Space Type ____

Schedule during months of ____

Days	M	T	W	Th	F	Sat	Sun	Hol.
Hours Open								
Hours Closed								
Peak no. of occupants								
Avg. no. of occupants when open								

Schedule during months of _______________________________________

Days	M	T	W	Th	F	Sat	Sun	Hol.
Hours Open								
Hours Closed								
Peak no. of occupants								
Avg. no. of occupants when open								

Building Shell Characteristics

Total exposed above-grade wall area (ft^2) ___________ Insulated? Y/N
Glazing area (% of exposed wall area) ___________ Single/Double?
Roof area (ft^2) ___________ Insulated? Y/N
Floor surface area exposed to outdoor conditions (ft^2) ___________ Insulated? Y/N
Above-grade wall area common with other conditioned building (ft^2)

Operation and Maintenance

Discuss/describe operation and maintenance procedures pertaining to building energy efficiency.
____
____
____
____
____
____
____

LIGHTING SYSTEMS DATA

Average installed load including ballast in more than 51%___________W/ft^2 of occupied space
Switches Accessible to more than 51% of occupants ________ Y/N?
Special Automatic Controls ________ Y/N?

Major Lighting Types 1 = Fluorescent 2 = Incandescent 3 = Mercury Vapor 4 = Sodium 5 = Metal Halide 6 = Other	% of Occupied Area

Heating, Ventilating, and Air-Conditioning System Data

Check all that apply in a significant way (affect > 5% of floor area or energy consumption)

Primary Cooling

- 10 Centrifugal Chiller [ ]
- 11 Reciprocating Chiller [ ]
- 12 Screw Chiller [ ]
- 13 Absorption Chiller [ ]
- 14 Package DX [ ]
- 15 Split DX [ ]
- 16 Air-Cooled Heat Rejection [ ]
- 17 Water-Cooled Heat Rejection [ ]

Primary Heating

- 20 Hot Water Boiler [ ]
- 21 Steam Boiler [ ]
- 22 Furnace [ ]
- 23 Ground-Source Heat Pump [ ]
- 24 Air-Source Heat Pump [ ]
- 25 Recirculating Water Source Heat Pump [ ]

AHU/Terminal Systems

- 30 Single Zone [ ]
- 31 Multi Zone [ ]
- 32 Dual Duct [ ]
- 33 Variable Air Volume [ ]
- 34 Reheat [ ]
- 35 Fan Coil Units [ ]
- 36 Unit Ventilators [ ]
- 37 Packaged Terminal Air Conditioners [ ]
- 38 Steam/Hot Water Radiators/Convectors [ ]
- 39 Above System(s) w/Economizer [ ]

Other

- 50 Cogeneration [ ]
- 51 Energy Monitoring and Control System [ ]
- 52 On-site Generation [ ]
- 53 Active Solar Equipment [ ]
- 54 Energy Recovery [ ]
- 55 Thermal Storage [ ]
- 56 Humidifiers/Dehumidifiers [ ]
- 57 Dessicant System [ ]
- 58 Evaporative Cooling [ ]
- 59 Other [ ]
  Define ____________________

Exhaust Systems

- 60 Fume Hoods, Constant Volume [ ]
- 61 Fume Hoods, VAV [ ]
- 62 Kitchen Hoods [ ]
- 63 Toilet [ ]
- 64 Locker [ ]
- 65 General [ ]

Unoccupied Setback

(check all that apply)

Shutdown of:

AHUs by Time Schedule		____________
Exhaust Fans by Time Schedule		____________
Chillers:		
	By Time Schedule	____________
	By Outside Air Temperature	____________
Boilers		
	By Time Schedule	____________
	By Outside Air Temperature	____________

SPECIAL LOADS

Significant energy requirements not normally associated with this building type (for example, unconditioned parking garage lighting or ventilation, outdoor heated pool, snow melting, extensive outdoor lighting, process)

	Peak Load		Avgerage Load		Operating	Period	Meter
Describe	kW	kBtu/h	kW	kBtu/h	h/wk	wk/yr	Number

Building and Systems Report

The forms in this section are intended to provide general guidance in preparing a report on the analysis of the building and its systems. It is not uncommon for the final report to be disseminated to and used by people with a wide variety of interests, including finance, management, operation, maintenance, and engineering. Therefore, within practical constraints of time and budget, the analyst is encouraged to be as thorough and clear as possible in collecting and presenting the measured data and the descriptions thereof.

Envelope Characteristics

Building ID ____

Date of Audit Month __________ Year ____________

Construction Code	R-Value	Glass Shading Coefficient	Area (ft^2)

(Include miniature building floor plan, showing orientation)

Construction Type Codes

Walls
- W0 = Other ______________
- W1 = Wood
- W2 = Masonry
- W3 = Concrete, Above Grade
- W4 = Concrete, Below Grade
- W5 = Metal
- W6 = Stone
- W7 = Glass
- W8 = Adjacent Building

Doors
- D0 = Other ______________
- D1 = Solid Wood
- D2 = Hollow Wood
- D3 = Uninsulated Metal
- D4 = Metal, Insulated Core
- D5 = Glass (<85%)

Roofs
- R0 = Other ____________________
- R1 = Concrete Deck
- R2 = Wood Deck
- R3 = Metal Deck

Windows

Sash Type
- G0 = Other __________________

Fixed, Wood Sash:
- G11 = Single Glaze G21 = Double Glaze

Operable, Wood Sash:
- G12 = Single Glaze G22 = Double Glaze

Fixed, Metal Sash:
- G13 = Single Glaze G23 = Double Glaze

Operable, Metal Sash:
- G14 = Single Glaze G24 = Double Glaze

LIGHTING SYSTEM CHARACTERISTICS

Describe in detail, include typical ceiling plans. Utilize space function format.	
• Typical W/ft^2	• Operating schedules
• Design of controls	• Operating and maintenance problems
• Typical W/ft^2 installed, by type of light source	
• Light levels, footcandles, 3 feet above floor, without daylight	
• % of lamps not functioning	

HVAC System Characteristics

Describe in detail, including floor plans and sketches.	
• Fuel Source	• Control Description and Setting
• Fuel Conversion Equipment	• Operating Periods
• Distribution Method	• Space Temperature Setting and Setback
• Terminal Type	• Operating and Maintenance Problems
• Equipment Capacity	

Heating System

____

____

____

____

Cooling System

____

____

____

____

Exhaust System(s)

____

____

____

____

INVENTORY OF MAJOR HVAC EQUIPMENT

This table format is intended as a guide. The information collected on systems need not be restricted to the format or categories below.

Designation	Location	Model/ Type	Size	Capacity	Serves	Operating Hours/Year	Remarks

DOMESTIC HOT WATER SYSTEM CHARACTERISTICS

Describe in detail:	
• Fuel Source	• Distribution
• Storage	• Setpoints
• Hours Operated	• Hours Required
	• Circulating Pump

Domestic Hot Water System

____

____

____

Other System Characteristics

Describe in detail, include schematics as needed. Include any operating and maintenance problems.

Laundry

Food Preparation

Conveying System (Elevators, etc.)

Other

Energy Analysis Summary and Recommendations

The forms in this section are intended to report the results of the calculations and recommendations of the analyst. The forms provide a breakdown of energy use and cost by system components as well as recommendations for modifications. System interaction must be properly accounted for when combining more than one modification. The economics of each modification may vary, depending upon the order in which they are accomplished.

Energy Analysis Summary

Building ID ______________________________

Date of Audit Month__________ Year _________

		kBtu ft²/yr	$/ft²/yr	$/yr
Actual Use	A			
Target[1]	B			
"Technical" Potential Savings	C (A-B)			
Savings from Measures Recommended for Implementation (see attached)	D			
Remaining Technical Potential Savings to be Defined	E (C-D)			
Realistically Achievable Potential Savings still to be Defined	F			
Total Achievable Savings	(D+F)			

Cost of Next Stage in Analysis $ ________ (G)

Cost of Measures Recommended (D) $ ________ (H)

Cost to Implement Potential Savings Still to be Defined (F) $ ________ (± ___ %)(I)

Total Implementation Cost (G+H+I) $ ________

1. Source: ______________________________

COMPONENTS OF ANNUAL ENERGY USE

	Electricity		Fuel	Other	Total	% of Total	Total	% of Total
	kWh	kBtu	kBtu	kBtu	kBtu	Use	Cost	Cost
Space Heating								
O.A. Heating								
Space Cooling								
O.A. Cooling								
Fans								
Pumps								
DHW Generator								
Lighting Within Conditioned Area								
Lighting Outside Conditioned Area								
Receptacles								
Kitchen								
Laundry								
Central Computer								
Conveyance								
Laboratory Equipment								
Other (describe)								
Unaccounted								
TOTAL						100%		100%

Recommended Energy Conservation Measures

Measure Description	Energy Type(s)	Units Saved	$/Year Saved	Implementation Cost	Extra Oper + Maint Cost	Simple Payback (Years)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
Total if all measures implemented						